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(71) Applicant: ITALIMPIANTI Società Italiana Impianti p.a.
Piazza Piccapietra, 9
I-16121 Genova(IT)

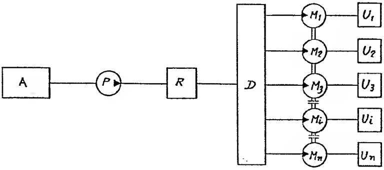
(72) Inventor: Tencati, Claudio
Via Olona 13
I-26100 Cremona(IT)

(72) Inventor: Boeddu, Bruno
Via P. Maroncelli 19
I-16153 Genova(IT)

(74) Representative: Porsia, Dino, Dr. et al,
c/o Succ. Ing. Fischetti & Weber Via Caffaro 3
I-16124 Genova(IT)

(54) **Method and plant for the distribution of the rate of flow of fuel oils to a plurality of users in industrial furnaces.**

(57) This invention relates to a method and plant for distributing fuel oils, possibly containing suspended particles, either in equal portions or in any other ratio, to a plurality of users (U1,2,3,m) or groups of users, such as burners, injectors or the like, in industrial furnaces. According to the invention, the oil to be distributed, preferably fed through a pumping station (P) and a flow regulator (R) to a feed manifold (D) is passed, downstream of the latter, as the driving oil through positive-displacement motors (M1,2,3,m) associated each to a user (U1,2,3,n) or a group of users and coupled mechanically and rigidly with each other through their shafts.



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ITALIMPIANTI Società Italiana Impianti p.a.,
Genoa, Italy.

Method and plant for the distribution of the rate of flow of fuel oils to a plurality of users in industrial furnaces.

This invention relates to a method and respective plant for distributing the rate of flow of any fuel oil, possibly containing suspended particles, either in equal portions or in any other ratio, to a plurality of users or groups of users, such as burners, injectors, or the like, in industrial furnaces, particularly heating furnaces, blast furnaces, and the like.

In the use of industrial furnaces, the problem often arises to distribute the rate of flow of fuel oil uniformly or in a pre-established ratio to a plurality of users or groups of users, such as to a plurality of burners, injectors, or the like. For this purpose, in order to balance the pressure in the various branches leading to the users, the design of the piping is

particularly important, especially as for the symmetry of geometry and distribution of concentrated and distributed pressure losses. Technical and economical optimization, practical requirements of installation, and usual construction and assembly procedures will cause, as for pressure losses, casual distributions either permanent or varying in the course of time and, anyway, different from the completely symmetrical and equal distribution to all users. This causes, when the users are connected to a plurality of outlet branches of the same manifold, fluctuations in the partial flowrates of oil to the individual users and casual variations in the response of regulation, as well as sensitiveness to any source of troubles and, in any case, an unstable operation.

The need exists, therefore, to find a method and plant to overcome these drawbacks and to ensure, in a technically and industrially reliable manner, the desired distribution of fuel oil to a plurality of users or groups of users in industrial furnaces.

For this purpose, the original design of a circuit was usually corrected by suitable calibration means, for example by the method of concentrated pressure losses which have a per cent noticeable value on the total balance of concentrated and distributed losses of the plant and are obtained, for example, by means of discs with calibrated nozzles, apertured nozzle plates, throttle valves and - to obtain a more accurate calibration - micrometric adjustment valves. This known method is simple

and of economic construction and assembly, but it requires long test periods on the plant to achieve a reliable adjustment. Moreover, it has the drawback whereby the more sensitive is the balancing effect, the higher is the per cent pressure loss with respect to the available pressure, and said balancing effect is reduced at low pressures. The concentrated pressure losses, used to obtain the desired flowrate distribution of fuel oil to the individual users, require an increase of the head needed by the plant. When the fuel oil to be distributed to the users contains suspended particles resulting, for example, from lack of filtration or from carryover of sludge and dirt from the piping, problems will rise due to obstruction of nozzles and calibrated holes and will cause the losses of balance load, with resulting loss of calibration and unstable operation of the plant. As a consequence, in case of critical operating conditions such as those mentioned above, the use of said known method requires frequent maintenance operations. The use of valves instead of nozzles or calibrated apertures is advantageous, especially during the initial adjustment, but it requires a new adjustment of the valves when the initial conditions are varied due to a variation of environmental conditions or to problems resulting from dirty conditions. All these disadvantages make this known method scarcely reliable, needy of frequent maintenance and/or calibration operations and, anyway, unsatisfactory whenever fuel oil might be polluted with solid particles having such a grain size as to obstruct any restricted passage. By said known method, the desired distribution can be ensured only in the event

of fuel oil flowrates which are sufficiently high both at maximum load and low load conditions. Moreover, during the first months of operation of the plant, residues resulting from machining and assembling operations, such as particles of teflon or lint, are carried over by the fuel oil, thus impairing the filtering action of the purposely-fitted devices and obstructing the calibrated passages or regulating means which determine the load balancing losses.

The need to avail, for a reliable flowrate distribution of fuel oil to various users, specifically industrial furnaces, of a dependable method regardless of the type of fuel oil and of the flowrate and pressure conditions, has led to the provision - for each user or group of users - of a proportioning positive-displacement pump, usually actuated by an associated 3-phase, asynchronous electric motor. By this method, the accurate distribution of the fuel oil flowrate to the various users is ensured by the constant displacement of the oil-displacing member in the pumps which are associated with said users. In this case, no limit exists as to the number of users and possible combinations. In order to avoid the peculiar sinusoidal periodical flowrate fluctuation in positive--displacement pumps, pumps with multiple displacing members are used and the delivery outlets of the individual displacing members are grouped. In order to permit any intervention on the plant downstream of a pump, with no need to inactivate the respective user, or the entire plant if a single motor operates all the pumps, suitable recirculation circuits are provided on the outlets of the

pumps. This method adopting proportioning pumps to distribute the flowrate of fuel oil, moreover, has the advantage that the overpressure generated by the pumps permits the circuit piping to follow even a complicated path, with no obligation as to symmetry and amount of pressure loss. By centralizing the distribution function in a single auxiliary device, maintenance operations are facilitated and replacement operations of the whole assembly are made easier and quicker. Since the flowrate is often regulated by acting directly on the geometry of the pumps, by varying the displacement thereof for all users, no problem arises - at any range of flowrates - as to transients, fluctuations and variations in the response of regulation. However, these advantages are obtained at a very high capital and running cost of the plant for flowrate distribution. In effect, the requirement of an accurate distribution requires pumps having a very high standard of accuracy, with very strict machining tolerances. The displacement of corrosive or hot oils requires high--quality materials. The particular requirements, compactness of the devices and type of regulation directly affect the variation of the displacement and thus create, generally, complicated and sophisticated constructions, to the detriment of the simplicity of operation, installation and maintenance, thus increasing the risk of malfunctioning and, above all, increasing considerably the capital and running costs.

Specifically, in the heating installations and in the heat-treatment furnaces using fuel oil, in order to

distribute said oil to the various burners, proportioning positive-displacement pumps of the axial plunger and rocking plate type are often preferred and are frequently connected in parallel to each other. For the reasons set forth above, the delivery outlets of a plurality of axial cylinders are connected together and are conveyed to a single user, while the regulation is effected by means of the rocking plate, thus changing the bottom dead center of the reciprocating plungers. The complicated and precision construction of this kind of pump creates a number of disadvantages. Thus, for example, the necessity of perfect seals often requires a lapped finish of certain surfaces, while the displacement of fuel oil always causes a noticeable surface abrasion and often compromises the machining accuracy, specifically of the pumping members. The use of a rocking plate as an operating member gives rise to possible scoring on this plate, and involves periodical grinding. The restoration of the original tolerances is needed after only few months of operation, and due to the complicated construction, the necessary grinding operations are very difficult and costly, and they can be effected only by the manufacturer of the pump.

This invention aims to overcome said disadvantages of the heretofore known methods and seeks, particularly, to increase the technical dependability in the industrial use thereof, and to reduce the capital and maintenance costs.

This object is achieved, according to the invention,

by a method as described in the preamble and substantially characterized in that the distribution of the flowrate of fuel oil to the various users is obtained by passing said oil as the driving oil through positive-displacement motors, each associated with a user or group of users and coupled mechanically and rigidly with each other through said shafts.

The plant according to this invention for carrying out said method is substantially characterized in that the fuel oil to be distributed is fed, preferably by means of a total flowrate regulator, to a distribution manifold, the outlets of the latter being connected each to the inlet of at least one positive-displacement motor the outlet of which is connected to a user or a group of users, while the shafts of these motors are rigidly connected to each other.

These and other characteristics of the invention and the advantages resulting therefrom will be apparent from the following description of a preferred embodiment thereof, illustrated as a non-limitating example in the single Figure of the accompanying diagrammatic drawing.

With reference to the drawing, U_1, U_2, U_3.....U_i, U_n indicate the individual users of the fuel oil to be distributed thereto. The users U_1.....U_n may be, for example, burners or groups of burners of an industrial furnace, or fuel injectors or groups of injectors for a blast furnace, or the like.

The plant for distributing the flowrate of fuel oil to the users $U_1.....U_n$ comprises a feeding source A which may be either a storage tank or a distribution system, or the like. The oil then passes through a pumping station P which raises its pressure, and successively through a flow regulator R. The oil is then fed at a constant flowrate to a distribution manifold D which is provided with an outlet for each user $U_1.....U_n$. Each outlet of the manifold D is connected to a respective user $U_1.....U_n$ through a positive-displacement motor M_1, M_2, $M_3.....M_i$, M_n. The inlet of each motor $M_1.....M_n$ is connected to the respective outlet of the manifold D, while the outlet of each motor $M_1.....M_n$ is connected to the associated user $U_1.....U_n$. The shafts of the motors $M_1.....M_n$ are mechanically coupled rigidly to each other. Various types of hydraulic motors may be used as positive--displacement motors $M_1.....M_n$, which fact permits the use of a type of motor most suited to fuel oil, such as gear motors, lobed wheel motors, vane motors, radial plunger motors, axial plunger motors, rocking ring motors, and the like, as well as any positive-displacement hydraulic motor, either existing or manufactured purposely for this invention. In the plant according to this invention, the pressurized fuel oil from the distribution manifold D is fed to the individual users $U_1.....U_n$ by passing as the driving fluid through the respective positive-displacement motors $M_1.....M_n$, which are thus actuated at rotational speeds (r.p.m.) which are identical to each other or have a given mutual ratio depending upon whether the shafts of the positive-displacement motors $M_1.....M_n$ are coupled

directly to each other with a 1 : 1 ratio or through the intermediary of speed reducers or multipliers, i.e. with a ratio different from 1 : 1. The partial flowrates passing through the individual positive-displacement motors $M_1 \ldots M_n$ to be fed to the respective users $U_1 \ldots U_n$, therefore, are pre-established exactly either as to their absolute amount and as to their mutual ratio, and since they depend upon the speed (rpm) and displacement of the respective motors $M_1 \ldots M_n$, said flowrates can be determined and changed by selecting and changing correspondingly either or both said factors (displacement and speed).

Thus, for example, when all positive-displacement motors $M_1 \ldots M_n$ have the same displacement and their shafts are coupled mechanically and rigidly to each other with a 1 : 1 ratio so as to rotate at the same speed, the partial flowrates distributed to the individual users $U_1 \ldots U_n$ are identical to each other. By varying the total flowrate by means of the regulator R, the distribution to the various users is correspondingly varied automatically because all the positive-displacement motors $M_1 \ldots M_n$ will rotate at lower but mutually identical speeds, whereby the partial flowrates distributed to the individual users $U_1 \ldots U_n$ are lower but always identical to each other.

In order to distribute the total flowrate according to pre-established ratios to the individual users $U_1 \ldots U_n$, each user can be fed through a positive-displacement motor $M_1 \ldots M_n$ the displacement of which is

proportional to the partial flowrate to be delivered to the associated user, while the shafts of all the motors $M_1.....M_n$ are rigidly coupled with each other with a 1 : 1 ratio, so as to obtain the same rotational speed of all said positive-displacement motors $M_1.....M_n$. Instead of feeding each user $U_1.....U_n$ through a single positive--displacement motor and of giving different displacements to these individual motors, it is possible to use - instead of at least one of the individual positive-displacement motors $M_1.....M_n$ - a group of two or more positive--displacement motors connected in parallel with each other to the distribution manifold D and to the respective user $U_1.....U_n$, the shafts thereof being connected rigidly to each other and to the shafts of the positive-displacement motors associated to the other users.

The distribution of the total flowrate according to pre-established ratios to the individual users $U_1.....U_n$ can be effected - rather than through motors having different displacements - by feeding the users $U_1.....U_n$ through positive-displacement motors $M_1.....M_n$ having the same displacement but coupled with each other at least partly by means of over-gear and/or reduction--gear devices, so as to rotate at different speeds with a ratio which corresponds to the desired ratio between the partial flowrates distributed to the users.

As a general rule, the positive-displacement motors $M_1.....M_n$ by means of which the total flowrate of fluid is distributed to the individual users $U_1.....U_n$ may

have any rate of flow and their shafts may be rigidly coupled with each other with such ratios whereby the products obtained by multiplying the displacement by the rotational speed of the individual motors $M_1.....M_n$ correspond to the partial flowrates to be delivered to the respective users $U_1.....U_n$.

In any case, the shafts of the positive-displacement motors $M_1.....M_n$ may be constructionally coupled with each other in various ways, such as by mechanically coupling said motors serially with each other, either directly and/or with the intermediary of suitable over-gear or reducing-gear means, or by coupling said motors in parallel with each other through their shafts to a suitable coupling, wherein the speed ratios between the individual positive-displacement motors $M_1.....M_n$ are pre-established (if desired, so as to be modified).

Moreover, the mechanical coupling between the positive-displacement motors $M_1.....M_n$ may be effected by means of disengageable clutches, if desired in combination with suitable by-pass drives, so as to permit the following operating conditions:

a) All positive-displacement motors $M_1.....M_n$ which are activated and mechanically coupled with each other, and all users $U_1.....U_n$, will operate at the respective partial nominal flowrates.

b) Disengagement of the mechanical coupling of one

or more positive-displacement motors $M_1.....M_n$ from the other positive-displacement motors, without discontinuing the oil supply to the disengaged motors and, therefore, to the respective users $U_1.....U_n$.

c) Inactivation of one or more users $U_1.....U_n$ without disconnecting the respective positive-displacement motors $M_1.....M_n$.

The method and plant according to the invention to distribute fuel oil to a plurality of users by means of positive-displacement motors which are mechanically and rigidly coupled with each other, eliminate the drawbacks of the heretofore known systems and grant some additional advantages with respect thereto.

In fact, the distributing plant according to the invention presents a great constructional and operational simplicity and is of low cost from the standpoint of manufacture, installation, assembly and operation, in that it permits the use of mass-produced and normally-marketed hydraulic motors (while permitting the use of purposely--manufactured motors), and eliminates or minimizes the use of skilled personnel. Moreover, the total flowrate regulator ensures a great simplicity of regulation. An accurate design of the piping geometry is no longer necessary, particularly as to symmetry and distribution of pressure losses, in that the plant according to the invention is self-controlled and automatically regulates itself according to the conditions of the circuit. In fact,

when the pressure losses in a branch associated to a user are higher or lower than the nominal value and the positive-displacement motor associated with said branch tends to reduce or to increase its speed with respect to the pre-established nominal speed, the mechanical rigid connection between the shafts of the individual positive--displacement motors ensures the preservation of the pre--established ratios between the rotational speeds of all said motors which will drive over or drag down the motor that tends to reduce or to increase its speed, thus ensuring the delivery of the same pre-established flowrate to the respective user. This peculiar and advantageous behaviour of the plant according to the invention is obtained automatically, with no regulating intervention from the exterior.

The plant according to the invention only requires few maintenance operations from time to time, because no problem exists as to soiling and obstruction of nozzles and the like. Therefore, the plant according to the invention only needs a short break-in period, with no need of repeated calibration and setup operations. An important advantage, particularly with respect to the known methods of flowrate distribution by means of proportioning pumps, resides in the fact that the distributing plant according to the invention is substantially operated by the pressure energy of the oil to be distributed, without any other mechanical intervention from the outside, thus eliminating all feed and regulation circuits for the external power and, consequently, all possible failures and troubles

which might result therefrom. The additional pressure energy to be given to the oil to be distributed is easily obtained by suitably oversizing the pumping station P. The higher cost resulting therefrom is, however, still lower that the cost involved by a plant with a plurality of proportioning pumps each actuated by its own motor. The characteristic feature whereby one single unit or group P is relied upon to deliver the oil at the pressure required by the plant, reduces the number of the required auxiliary and safety devices. At the same time, each user or group of users is associated with a suitable distributing member constituted by the respective positive-displacement motor, thus facilitating the maintenance operations, in that these motors may be replaced to permit easier and more accurate repairs in a suitable workshop, rather than repairs on a running plant with the risk of affecting the respective users. Since the flowrate regulation is carried out by means of a single regulator on the total flowrate, and the partial flowrates to the individual users are regulated accordingly automatically, the distributing plant according to the invention avoids the technical problems existing in a plant comprising proportioning pumps and with complicated construction and regulation. All transmissions, electrical circuits and electrical--mechanical transducers required by the proportioning pumps are eliminated, thus ensuring a more reliable operation. The plant according to the invention, therefore, has lower capital and running costs and is of greater technical reliability to meet the most various industrial requirements, where an accurate distribution of the rate

of flow of any incompressible fluid is necessary.

Of course, the invention is not limited to the embodiments here shown and described merely by way of example, but changes and modifications, especially of constructional nature, can be broadly made thereto without departing from the basic principle set forth above and claimed hereinafter.

CLAIMS

1. A method for distributing the rate of flow of any fuel oil, which may possibly contain suspended particles, either in equal portions or in any other ratio, to a plurality of users ($U_1 \ldots U_n$) or groups of users in industrial furnaces, characterized in that the oil to be distributed is passed as the driving fluid through positive-displacement motors ($M_1 \ldots M_n$) associated each to a user or group of users and coupled mechanically and rigidly with each other through their shafts.

2. A plant for carrying out the method according to claim 1, characterized in that the fuel oil to be distributed is fed to a distribution manifold (D) the outlets of which are connected each to the inlet of at least one positive-displacement motor ($M_1 \ldots M_n$) the outlet of which is connected to a user or group of users, and the shafts of the positive-displacement motors interposed between the distribution manifold (D) and the users ($U_1 \ldots U_n$) or group of users are rigidly coupled with each other.

3. A plant according to claim 2, characterized in that the product obtained by multiplying the displacement by the rotational speed of each positive-displacement motor ($M_1 \ldots M_n$) gives the partial flowrate fed to the respective user ($U_1 \ldots U_n$) or group of users.

4. A plant according to claims 2 and 3, characterized

in that at least some positive-displacement motors (M_1.....M_n) have the same displacement but different rotational speeds.

5. A plant according to claims 2 and 3, characterized in that at least some positive-displacement motors have the same rotational speed but different displacements.

6. A plant according to claims 2 and 3, characterized in that at least some positive-displacement motors have different displacements and different rotational speeds.

7. A plant according to any one or more of the claims 2 to 6, characterized in that the shafts of at least two positive-displacement motors are coupled with each other with a velocity ratio of 1 : 1.

8. A plant according to any one or more of claims 2 to 7, characterized in that the shafts of at least two positive-displacement motors are coupled with each other with a velocity ratio different from 1 : 1.

9. A plant according to any one or more of claims 2 to 8, characterized in that at least one outlet of the distribution manifold (D) is connected to the respective user (U_1.....U_n) or group of users by means of at least two positive-displacement motors inserted in parallel, the shafts of which are rigidly coupled with each other and with the shafts of the positive-displacement motors which are associated to the other users.

10. A plant according to any one or more of claims 2 to 9, characterized by means selectively permitting the plant to operate either with all positive-displacement motors inserted in the oil circuit and coupled with each other and with all users operating at the respective partial nominal flowrates, or with one or more positive--displacement motors disconnected from the system, without discontinuing the delivery of oil to the users, or with one or more inactivated users, without disconnecting the respective positive-displacement motor (or motors) from the system.

11. A plant according to any one or more of claims 2 to 10, characterized in that the positive--displacement motors may be constituted by any type of hydraulic motors, either of known and available type or of purposely-manufactured type, such as gear motors, lobed wheel motors, vane motors, axial plunger motors, radial plunger motors, rocking ring motors, or the like.

12. A plant according to any one or more of claims 2 to 11, characterized in that the oil to be distributed is fed to the distribution manifold (D) through a flowrate regulator (R) adapted to constantly maintain the total flowrate at an adjustable level.

13. A plant according to any one or more of claims 2 to 12, characterized in that the oil to be distributed is fed to the distribution manifold (D) through a unit adapted to increase the pressure of the oil.

14. A method and a plant for distributing the flowrate of fuel oil to a plurality of users in industrial furnaces by means of positive-displacement motors, the whole or in part substantially as described, as shown and for the specified purposes.

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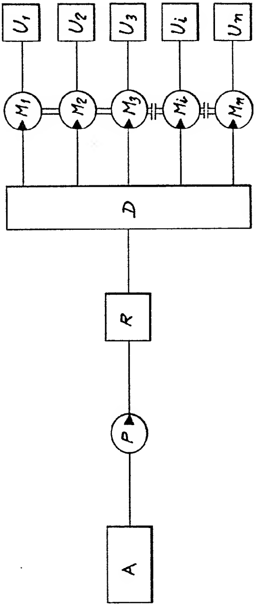

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EUROPEAN SEARCH REPORT

0118770
Application number

EP 84 10 1329

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	DE-C- 322 259 (DELAUNAY-BELLEVILLE) * Page 2, lines 61-121; claim 1; figures *	1-3,5, 7,9-14	F 23 K 5/00
Y	GB-A-2 057 572 (WHITE et al.) * Page 1, lines 33-77; page 2, lines 31-71; figures 1,2,3 *	1-3,5, 7,9-14	
A	DE-A-2 016 171 (PLESSEY CO.)		

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

F 23 K
F 04 B
F 02 M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-07-1984	COMEL E.

CATEGORY OF CITED DOCUMENTS

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